Thermal Management

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- Capillary Devices(loop heat pipes(LHP), capillary pumped loops(CPL))
  - Needs: Lack of detailed understanding of capillary devices precludes new designs for new applications in a cost-effective manner
  - Current LOU: General empirical understanding of how these devices work under steady state conditions
  - Desired Improvements:
    - **Near**: CPL start-up (which includes pressure spike), boiling incipience,vapor (bubble) growth, porous media transient vapor and liquid flow.
    - **Mid term:** LHP hysteresis, miniaturization(scaling), complex geometries, high flux, conductance
    - **Long term**: supercapacity wicking structures, very large devices, nano devices
  - Outcome:
    - **Near:** greater reliability and system safety,on-demand operation, better knowledge of design margin

Thermal Management, Continued

- **Mid term:** new applications for CPL, LHP.
- **Long term:** new applications possibly eliminating mechanical pumps (e.g.3rd Gen RLV)

–Approach:

- 1) Instrumentation and Flow Visualization
- 2) Phenomenological/Analytical/Computational based on ground and space-based experiment observation (e.g. Mars G, Moon G, Microgravity)

–Cross Cutting: Power (fuel cell fluid management) ISRU, Propellant

Thermal Management

- ***Non -*** Capillary Devices(mechanical, vapor, electrohydrodynamic, etc.)
  - Needs: Need to dissipate high heat fluxes and/or high power levels (e.g. > 100 kW)
  - Current LOU: Very limited understanding of flow regimes, pressure drops and heat transfer (boiling and condensation) under reduced gravity of varying gravity conditions, phase separation. No understanding of burnout (CHF),especially low velocity flows required for low pressure drop.
  - Desired Improvements/Outcome:
    - **Near**: several hundred W/cm2
    - **Mid term:** several hundred W/ cm2
    - **Long term**: flexibility to design high performance cooling systems for a variety of fluids and packaging geometries
  - Approach:
    - 1) Instrumentation and Flow Visualization up to and including burnout
    - 2) Phenomenological/Analytical/Computational based on ground and space-based experiment observation (e.g. Mars G, Moon G, Microgravity)
  - Cross Cutting: ISRU, Propellant, Life Support

Thermal Management

- ***Other Topics-***
  - Scaling
  - Variable G Environments
  - Closer Collaboration between Universities, Government and Industry;Joint research effects on critical technologies
  - Explore the extremes in fluid property variation ranging from cryogenic to liquid metals
  - Miniaturization (nano- meso- micro)
  - Cryogenic Maintenance, Cryogenic Fluid Management
  - Phase change materials (solid-liquid) for transient energy thermal management
  - Enhanced Student participation in NASA research projects
  - Incorporate microgravity thermal considerations early in thermal design.